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## THURSDAY SESSIONS VOLUME II

### **An Assessment of Early Competitive Prototyping for Major Defense Acquisition Programs**

William Fast, COL, U.S. Army (Ret.), Senior Lecturer, NPS

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## Panel 12. Considerations for Focusing Development and Controlling Growth in MDAPs

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Thursday, May 5, 2016	
9:30 a.m. – 11:00 a.m.	<p><b>Chair: Nancy Spruill</b>, Director, Acquisition Resources &amp; Analysis, Office of the Under Secretary of Defense for Acquisition, Technology, &amp; Logistics</p> <p><b><i>Blockmodeling and the Estimation of Evolutionary Architectural Growth in Major Defense Acquisition Programs</i></b> LTC Matthew Dabkowski, U.S. Army, University of Arizona Ricardo Valerdi, Associate Professor, University of Arizona</p> <p><b><i>An Assessment of Early Competitive Prototyping for Major Defense Acquisition Programs</i></b> William Fast, COL, U.S. Army (Ret.), Senior Lecturer, NPS</p> <p><b><i>The Sixth-Generation Quandary</i></b> Raymond Franck, Professor Emeritus, U.S. Air Force Bernard Udis, Professor Emeritus, University of Colorado at Boulder</p>



# An Assessment of Early Competitive Prototyping for Major Defense Acquisition Programs

**William R. Fast, COL, USA (Ret.)**—has been a Senior Lecturer in Acquisition in the Graduate School of Business and Public Policy at the Naval Postgraduate School since September 2010. Prior to that, he taught acquisition and business, cost estimating, and financial management courses at the Defense Acquisition University. Fast is credentialed by the American Society of Comptrollers (ASMC) as a Certified Defense Financial Manager with Acquisition Specialty (CDFM-A). [wrfast@nps.edu]

## Abstract

On May 22, 2009, the President signed into law the Weapon System Acquisition Reform Act of 2009 (WSARA). An important feature of WSARA is the requirement for all Major Defense Acquisition Programs (MDAPs) to conduct competitive prototyping prior to the Milestone B development decision. These prototypes must be demonstrated in a relevant environment to provide the milestone decision authority (MDA) with an assessment of their level of technology maturity. Competitive prototyping in this early phase can also identify program risk and help the MDA decide if there is a good match between the customer's needs and the available resource—technology, design, time, and funding. However, if the MDA determines that there is little or no benefit, competitive prototyping can be waived. The rationale behind such a waiver must be provided to the Government Accountability Office (GAO). The WSARA competitive prototyping requirement has now been in effect for nearly seven years. There is a considerable amount of data on the costs and benefits of early competitive prototyping efforts. In addition, the GAO has published numerous opinions regarding MDA waivers of competitive prototyping. This research analyzes MDAP data from the 2013, 2014, and 2015 Annual Reports on the Performance of the Defense Acquisition System, the Defense Acquisition Management Information Retrieval (DAMIR), Budget Exhibits that accompany the President's annual budget request, the Director of Operational Test and Evaluation (DOT&E), and the GAO. This research finds that early competitive prototyping has received only partial implementation for pre-MDAP and MDAP programs. However, when implemented, early competitive prototyping has reduced Program Acquisition Unit Cost (PAUC) and has reduced technology risk.

## Research Questions

1. What MDAPs, entering the EMD phase after May 2009, have received a waiver from competitive prototyping prior to Milestone B? What were the most common reasons for these waivers? Did the GAO concur with these waivers and, if not, why not?
2. What MDAPs, entering the EMD phase after May 2009, have conducted competitive prototyping prior to Milestone B? For these MDAPs, what were the results of competitive prototyping in terms of technology maturity, design risk reduction, development cycle time, and cost estimate/funding stability, and system performance?
3. Based upon the answers to research questions 1 and 2, has the WSARA early competitive prototyping requirement helped reduce MDAP Program Acquisition Unit Cost (PAUC) and technology risk?

## Background

Section 203 of the Weapon System Acquisition Reform Act (WSARA) of 2009 requires that the acquisition strategies for Major Defense Acquisition Programs (MDAPs) provide for competitive prototyping prior to the Milestone B approval. The Milestone Decision Authority (MDA) may waive the competitive prototyping requirement only on the basis that



a) the cost of producing competitive prototypes exceeds the expected life-cycle benefits (in constant dollars) of producing such prototypes, including the benefits of improved performance and increased technological and design maturity that may be achieved through competitive prototyping; or b) on the basis that, but for such waiver, the Department would be unable to meet critical national security objectives. (WSARA, 2009, § 203)

The language of Section 203 was later modified to clarify that prototypes may be acquired from commercial, government, or academic sources and, if prototyping of the system is not feasible, prototypes may be acquired for critical subsystems (WSARA, 2009, § 813).

To better understand this statute, several terms must be defined. First, there are generally two types of prototyping incorporated into acquisition strategies. Early prototyping is done in the Technology Maturation and Risk Reduction (TMRR) phase of the program, prior to Milestone B. Prototyping does occur later, after Milestone B, when Engineering Design Models (EDM) are built in the Engineering and Manufacturing Development (EMD) phase of the program. However, the intent of the WSARA of 2009 is for MDAPs to have early prototypes, prior to approval of Milestone B.

Competitive prototyping involves two or more contractors developing prototypes and verifying (through testing or demonstration) that they meet contractual requirements. Ideally, after the contractor builds and demonstrates or tests the prototype, the government and contractor conduct a Preliminary Design Review (PDR). The purpose of the PDR is to assess the results of the prototyping effort and to conduct cost, schedule, and performance trades to meet user requirements, schedule, and resources. For example, some operational requirements may have to be deferred to a later increment of the program because certain critical technologies were determined as immature while testing a competitive prototype.

A Major Defense Acquisition Program (MDAP) is a program that expects to expend more than \$480 million in Research, Development, Test, and Evaluation (RDT&E; FY2014 constant dollars) or \$2.79 billion in procurement (FY2014 constant dollars) for all of its increments (10 U.S.C. § 2430). However, at the time that the WSARA of 2009 was enacted, the RDT&E expected expenditure threshold for an MDAP was \$365 million and the procurement expected expenditure threshold was \$2.19 billion (FY2000 constant dollars).

When a program is designated as an MDAP, the Milestone Decision Authority (MDA) is either the Under Secretary of Defense for Acquisition, Technology and Logistics (who is also the Defense Acquisition Executive, DAE) or the designated Component Acquisition Executive (CAE). The MDA determines when programs move from one acquisition phase to the next by reviewing program accomplishments at the various milestone reviews throughout the acquisition framework (DoDI, 2015a).

Since the WSARA of 2009 was enacted, DoD Instruction 5000.02, Operation of the Defense Acquisition System, has changed three times. To accommodate these changes, only the current names for acquisition phases, reviews, and capability documents are used throughout this paper.

## **Literature Review**

The only published research on the implementation of early prototyping by MDAPs since 2009 are the Government Accountability Office (GAO) annual Assessments of Selected Weapon Programs. Recently, these assessments have been based upon an electronic questionnaire sent to selected program management offices. GAO pre-tests their questionnaire to ensure that the program offices of each Service understand the terminology used in the questionnaire. One set of questions in the survey asks if the program has



attained knowledge that all of its critical technologies work in a relevant environment and in a realistic environment. Technologies that work in a relevant environment would be assessed at Technology Readiness Level (TRL) 6. Technologies proven to work in a realistic environment would be assessed at TRL 7. However, neither of these questions specifically ask if the technologies were demonstrated on early competitive prototypes. The program offices could have demonstrated the technology on components, subsystems, or even on a single prototype, rather than on competitive prototypes. Therefore, the results of the electronic questionnaire are inconclusive as to whether early competitive prototyping was actually used.

The program offices most certainly answer these two GAO questions based upon their interpretation of the early competitive prototyping requirement. For example, the F-22 Increment 3.2B Modernization (F-22 Inc 3.2B Mod) program office reported to the GAO that all critical technologies were demonstrated in a relevant environment prior to Milestone B. However, there is no evidence in any independent source documents that confirms that competitive prototypes were used for that technology assessment or that the critical technologies were tested on even a single prototype. Thus, based upon the GAO report, we can only assume that the program office tested the critical technologies on components or subsystems, but not using an integrated system prototype. Similar assumptions must be made for the K-46A Tanker Modernization program and the Global Positioning System (GPS) Next Generation Operational Control System (OCX)—no competitive prototypes or even a single prototype was developed and tested.

The other disconnect in the GAO questionnaire results involves programs that have had competitive and single prototype waivers. For example, the Combat Rescue Helicopter (CRH) program received a waiver from early prototyping. In the business case analysis for that waiver, the CRH program office reports that critical technologies are mature. Yet, in response to the GAO questionnaire, the CRH program office says that information is not available as to whether critical technologies have been demonstrated in a relevant or a realistic environment. A different kind of disconnect is seen in the Armored Multi-Purpose Vehicle (AMPV) and the VH-92A Presidential Helicopter Replacement (VH-92A) programs. In these two programs, the program offices report the demonstration of critical technologies in a relevant environment, yet both programs received prototyping waivers (and the GAO clearly states this in the assessment of the AMPV program). So, these two program offices must be referring to component or subsystem prototyping (GAO, 2015a).

## Methodology

This research effort used only objective evidence, not questionnaires filled out by program offices that could be biased or open to interpretation. First, all new MDAPs entering the EMD phase since 2009 were identified by extracting new programs first reporting a development baseline in the Selected Acquisition Report (SAR) summary tables. SARs on all MDAPs are prepared by the Department of Defense (DoD) and sent to the Congress annually. Second, pre-MDAP programs that had early competitive prototyping efforts since 2009 were identified from the data reported in the Defense Acquisition Management Information Retrieval (DAMIR).

Several new MDAPs did not have an early prototyping effort because they were granted a waiver by the Milestone Decision Authority (MDA). In accordance with the WSARA of 2009, the MDA's rationale for granting a waiver from competitive prototyping must be reported to the Comptroller General of the United States. The GAO assesses this rationale and sends a written report of their findings to the congressional defense committees. Copies of these waiver assessments are publicly available on the GAO



website. All GAO assessments of competitive prototyping waivers since 2009 were reviewed, to include the rationale for the waiver. For example, was the waiver based upon National Security urgency? Or, was the waiver based upon a cost benefit analysis (CBA) where the costs of prototyping outweighed the dollarized benefits in constant dollars? If the waiver was based upon a CBA, then answers were sought for these additional questions:

- What were the costs and benefits cited in the CBA? Were the costs and benefits properly determined and compared?
- What type of contract was subsequently used in the EMD phase? If a firm fixed price-type contract was used in the EMD phase, it may be that there was little to no technical risk. That would validate the decision to waive early prototyping.
- What was the baseline cost estimate for Program Acquisition Cost (in constant dollars), and what was the quantity established at the development baseline (i.e., program initiation and the first SAR to Congress)? What is the current Program Acquisition Cost estimate (in constant dollars) and what is the quantity reported in the 2015 SAR? Is there evidence of cost growth or cost reduction between the Program Acquisition Unit Cost (PAUC) at the development baseline and the current PAUC as of the 2015 SAR?

For each MDAP that did not have a competitive prototyping waiver, the type of early prototyping done prior to the Engineering and Manufacturing Development (EMD) phase was identified (i.e., subsystem/component prototypes, a single system prototype, and competitive prototypes). Then, these questions about those prototyping efforts were answered:

- What early prototypes were built, and how were they tested? Whenever available, independent reports of test efforts by the DoD Director of Systems Engineering, the DoD Director of Developmental Testing, and the DoD Director of Operational Testing were used.
- What technology readiness levels (TRL) and manufacturing readiness levels (MRL) resulted from the prototyping effort? Whenever available, independent TRL/MRL assessments by the DoD Director of Systems Engineering were used.
- What type of contract was used in the TMRR phase for the prototyping effort, and what type of contract was subsequently used in the EMD phase? When available, contract types were taken from Form R-3 Budget Exhibits. The point of asking this question is to understand the level of technical risk, especially after early prototyping. For example, if a Cost Plus Fixed Fee (CPFF) contract was used in the EMD phase, one might question whether the early prototyping effort revealed the technical maturity of the design.
- What was the baseline cost estimate for Program Acquisition Cost (in constant dollars), and what was the quantity established at the development baseline (i.e., program initiation and the first SAR to Congress)? What is the current Program Acquisition Cost estimate (in constant dollars) and what is the quantity reported in the 2015 SAR? Is there evidence of cost growth or cost reduction between the Program Acquisition Unit Cost (PAUC) at the development baseline and the current PAUC as of the 2015 SAR?





## Findings

Since the enactment of the WSARA of 2009, there have been about 28 pre-MDAP or MDAP programs subject to statutory competitive prototyping requirements. These programs can be placed into three categories as shown in Table 1.

**Table 1. Pre-MDAPs and MDAPs Subject to Statutory Prototyping Since 2009**

Waiver	No Prototyping	Prototyping
• AMPV	• B61 Mod 12 LEP TKA	• AMDR
• B-2 DMS Mod*	• F-22 Inc 3.2B Mod	• Chem Demil-ACWA
• CRH	• FAB-T FET	• EPS
• EPS CAPS	• GPS OCX	• F-35 Aircraft
• F-15 EPAWSS*	• ICBM Fuze Mod	• F-35 Engine
• IFPC Inc 2 Blk 1	• KC-46A	• JAGM
• T-AO (X)*	• LCS MM	• JLTV
• VH-92A		• LCS
		• NGJ*
		• SDB II
		• SF
		• SSC
*pre-MDAP		• 3DELRR*

The next three sections summarize the common characteristics of the programs with prototyping waivers, no prototyping, or prototyping efforts.

### Waivers

Since the enactment of the WSARA of 2009, 8 pre-MDAP or MDAP programs received a waiver from early prototyping (see Table 1). A description of each of these programs and their cost benefit analyses are at Appendix A. The findings follow:

- **Rationale Behind Waivers.** Seven (7) of these waivers were based upon the rationale that the cost of producing the competitive prototypes outweighed the life-cycle benefits of the prototyping effort. The waiver for EPS CAPS was based upon the rationale that the cost of prototyping outweighed the benefits and that the delay caused by prototyping would jeopardize National Security.
- **GAO's Assessments.** In most cases, the GAO's assessments found that the rationale behind the prototyping waivers was consistent with the intent of the WSARA of 2009. However, in assessing the waivers for AMPV, EPS CAPS, B-2 DMS-M, EPS CAPS, and VH-92A, the GOA questioned whether a sufficient number of prototyping alternatives had been analyzed or criticized the effort (or lack of effort) to dollarize prototyping benefits.
- **Some Waivers Supported by Acquisition Strategy.** Acquisition strategies to reduce technology risk by using only mature technologies and/or by reducing user requirements often obviated the need for early risk reduction prototyping. This was the case with the waivers for AMPV, CRH, F-15 EPAWSS, IFPC Inc 2 Blk 1, T-AO(X), and VH-92A.
- **Cost Reimbursement Contract for EMD Questioned.** The GAO's assessments of the prototyping waivers always questioned whenever a cost reimbursement-type contract was used or proposed for the EMD phase. Their rationale is that early prototyping may reduce technology risk, permitting the





use of a fixed price-type contract for the EMD phase. Two areas of risk often identified as justifying the use of cost reimbursement-type contracts were software development and integration. This was the case with the waivers for AMPV, B-2 DMS Mod, and EPS CAPS.

- **Schedule Impacts Not Quantified in Dollars.** Schedule impacts due to prototyping were discussed in 6 of the 8 waivers. Depending on the number of competing contractors, the delays due to prototyping ranged from 6 months to 60 months. However, none of the schedule impacts appear to have been added into the cost of the prototyping effort for direct comparison to the benefits in dollars.
- **BCA Not Posted With Waiver Assessment.** The business case analysis (BCA) done by the program office was not posted along with the GAO assessment of the waiver. Had the BCA been made available, it might have been useful in answering some of these research questions. More importantly, a copy of the BCA posted with the GAO assessment of that BCA could be a good teaching tool for the Defense Acquisition Workforce.
- **ASD Acquisition Comments on GAO Assessments.** The Assistant Secretary of Defense for Acquisition commented on three of the GAO's waiver assessment reports that *"competitive prototyping needs to be tailored to the needs and risks of each specific program, balanced with any potential adverse cost and schedule impact."* This comment may indicate that the ASD Acquisition has a different interpretation of the early prototyping requirement than does the GAO.

### **No Prototyping**

Since the enactment of the WSARA of 2009, seven (7) pre-MDAP or MDAP programs did not conduct any early prototyping (see Table 1). A description of each of these programs is at Appendix B. The findings follow:

- **Programs Started in EMD Phase.** All 7 of these programs may have assumed that just because they bypassed the TMRR phase and started in the EMD phase, they didn't have to do competitive prototyping. However, that assumption is clearly not the intent of the WSARA of 2009 which states that competitive prototyping is required before Milestone B (per Section 203 of the WSARA of 2009). All of these programs had to go through Milestone B before entering the EMD phase. In addition, prior to the Milestone B decision, the Milestone Decision Authority must certify, to the Congress, that the technology in the program has been demonstrated in a relevant environment (TRL 6) and that the program complies with all relevant policies, regulations, and directives of the Department of Defense (per 10 U.S.C. § 2366b). DoDI 5000.02, *Operation of the Defense Acquisition System*, has required competitive prototyping since 2008.
- **Reductions in PAUC.** When the Program Acquisition Unit Cost (PAUC) in constant dollars, based upon the development (EMD) baseline, is compared to the current PAUC in constant dollars, based upon the 2015 Annual SAR, four (4) of the programs have shown a reduction in PAUC. The B61 Mod 12 LEP TKA program has the largest reduction in PAUC at -9.6%. The LCS MM program has the smallest reduction in PAUC at -0.1%.
- **Increases in PAUC.** When the Program Acquisition Unit Cost (PAUC) in constant dollars, based upon the development (EMD) baseline, is compared



to the current PAUC in constant dollars, based upon the 2015 Annual SAR, three (3) of the programs have shown an increase in PAUC. The GPS OCX program has the largest increase in PAUC at +21.2%. The ICBM Fuze Mod program has the smallest increase in PAUC at +1.0%.

- **Cost Reimbursement Development (EMD) Contracts.** Five (5) of the programs awarded a cost reimbursement-type contract for the development (EMD) phase. Cost Plus Fixed Fee (CPFF) contracts were awarded for ICBM Fuze Mod and LCS MM. Cost Plus Award Fee (CPAF) contracts were awarded for GPS OCX and LCS MM. Cost Plus Incentive Fee (CPIF) contracts were awarded for B61 Mod 12 LEP TKA and F-22 Inc 3.2B Mod. The determination of the contract type for the development (EMD) phase of an MDAP is the responsibility of the Milestone Decision Authority (MDA). If the MDA selects a cost reimbursement-type contract for the development (EMD) phase, this decision has to be justified to the Congress. In the justification, the MDA is to explain why the technology is so immature that a cost reimbursement contract is necessary (DoD, 2015a).
- **Identification of Critical Technology Elements.** Software development and system integration were often not considered as critical technology elements that could be assessed and matured through early prototyping. This was the case with F-22 Inc 3.2B Mod, GPS OCX, and LCS MM.

### ***Prototyping***

Since the enactment of the WSARA of 2009, thirteen (13) pre-MDAP or MDAP programs did conduct early prototyping (see Table 1). A description of each of these programs is at Appendix C. The findings follow:

- **Types of Prototyping Used.** All 13 of the programs used some type of prototyping permitted under the WSARA of 2009. One (1) program (Chem Demil-ACWA) prototyped two separate components. One (1) program (SSC) used a subsystem prototype. Eleven (11) programs (AMDR, EPS, F-35 Aircraft, F-35 Engine, JAGM, JLTV, LCS, NGJ, SDB II, SF, and 3DELRR) used 2 or more subsystem or competitive prototypes.
- **Reductions in PAUC.** When the Program Acquisition Unit Cost (PAUC) in constant dollars, based upon the development (EMD) baseline, is compared to the current PAUC in constant dollars, based upon the 2015 Annual SAR, eight (8) of the programs have shown a reduction in PAUC. The SDB II program has the largest reduction in PAUC at -21.3%. The EPS program has the smallest reduction in PAUC at -0.6%.
- **Increases in PAUC.** When the Program Acquisition Unit Cost (PAUC) in constant dollars, based upon the development (EMD) baseline, is compared to the current PAUC in constant dollars, based upon the 2015 Annual SAR, three (3) of the programs have shown an increase in PAUC. The Chem Demil-AWCA program has the largest increase in PAUC at +3.0%. The JAGM program has the smallest increase in PAUC at +0.2%.
- Two (2) pre-MDAP programs (NGJ and 3DELRR) did not have development (EMD) baselines from which to determine any increase or decrease in PAUC.
- **Fixed Price Development (EMD) Contracts.** Five (5) of the programs awarded a fixed price-type contract for the development (EMD) phase. Fixed Price Incentive (Firm Target; FPIF) contracts were awarded for LCS, SDB II, SF, and SSC. A Firm Fixed Price (FFP) contract was awarded for JLTV. Use



of a fixed price-type contract is an indication that technology is mature and cost risk has been reduced.

- **Cost Reimbursement Development (EMD) Contracts.** Five (5) of the programs were awarded a cost reimbursement-type contract for the development (EMD) phase. Cost Plus Award Fee (CPAF) contracts were awarded for Chem Demil-ACWA, F-35 Aircraft, and F-35 Engine. Cost Plus Incentive Fee (CPIF) contracts were awarded for AMDR, Chem Demil-ACWA, EPS, F-35 Aircraft, and F-35 Engine. The determination of the contract type for the development (EMD) phase of an MDAP is the responsibility of the Milestone Decision Authority (MDA). If the MDA selects a cost reimbursement-type contract for the development (EMD) phase, this decision has to be justified to the Congress. In the justification, the MDA is to explain why the technology is so immature that a cost reimbursement contract is necessary (DoD, 2015a).
- Two (2) programs have yet to award contracts for the EMD phase. These are both pre-MDAP programs: NGJ and 3DELRR.

## Conclusion

This research finds that early competitive prototyping has received only partial implementation for pre-MDAP and MDAP programs. However, when implemented, early competitive prototyping in the TMRR phase does reduce technology and cost risk going into the EMD phase and does reduce Program Acquisition Unit Cost (PAUC) as measured from the development (EMD) baseline estimate.

Eight (8) pre-MDAP or MDAP programs entering EMD after May 2009 have received waivers from competitive prototyping prior to Milestone B. The most common reason for these waivers was that the cost of early prototyping exceeded the life-cycle benefits in constant dollars. While the GAO assessed that the rationale behind each of these waivers was consistent with the WSARA of 2009, deficiencies in the supporting business case analyses were exposed. The Defense Acquisition Workforce would benefit from training in the identification of viable prototyping scenarios and how to estimate the life-cycle benefits (in dollars) that can accrue from prototyping.

Thirteen (13) pre-MDAP or MDAP programs entering EMD after May 2009 conducted competitive prototyping prior to Milestone B. These programs are showing more reduction in PAUC compared with the programs for which prototyping was waived or the programs that did not use early prototyping. In addition, the fact that many of these programs were able to use a fixed price-type contract in their EMD phase points to a reduction in technology and cost risk as a result of competitive prototyping.

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## Appendix A. Waivers

1. **Armored Multi-Purpose Vehicle (AMPV) Program.** The Army's AMPV fleet is to replace the M113 family of vehicles. The AMPV will come in five variants: general purpose, medical evacuation, medical treatment, mortar carrier and mission command. The AMPV program acquisition strategy is based on modifying an existing and operationally proven military vehicle and plans to bypass technology development and begin in system development. The Army has also modified or eliminated some AMPV requirements to ensure that no technology development is needed for the AMPV (GAO, 2014c).
  - Costs Estimated for Prototyping Alternatives. (1) One contractor producing 5 variants (\$198M); (2) Two contractors producing 5 variants each and 1 Live Fire Test & Evaluation vehicle each (\$341M).
  - Benefits Estimated. (1) None (\$0); (2) None (\$0).
  - Schedule Impact. (1) 19 months; (2) 31 months.
  - Type Contract for TMRR phase. None.
  - Type Contract for EMD phase. Cost Plus Incentive Fee (CPIF) with 70/30 share ratio.
  - Percent change in PAUC from development baseline. +0.2%.
2. **B-2 Defensive Management System Modernization (B-2 DMS Mod) Program.** The B-2 DMS Mod will detect, identify, and locate enemy radar systems and provide real-time threat avoidance, threat warning, and threat situational awareness information to the aircrew. The program is an analog to digital upgrade that consists of three subsystems (antenna, electronic support measures, and avionics and graphics processors) integrated onto existing B-2 aircraft. Entry into the EMD phase was in late fiscal year 2015 (GAO, 2014b). The prime contractor has conducted competitions for three key subsystems—antennas, processors, and electronic support measures. Competitive prototyping was also conducted for the antennas (GAO, 2015a).
  - Costs Estimated for Prototyping Alternatives. (1) System prototyping by a separate contractor from Northrup Grumman (\$524.8M); (2) Subsystem prototyping (\$28.5M).
  - Benefits Estimated. (1) \$6.3M; (2) \$1.3M.
  - Schedule Impact. (1) Unknown; (2) Unknown.
  - Type Contract for TMRR phase. None.





- Type Contract for EMD phase. Cost Reimbursement.
  - Percent change in PAUC from development baseline. Unknown.
3. **Combat Rescue Helicopter (CRH) Program.** The Air Force's CRH program will replace legacy HH-60G Pave Hawk helicopters. The CRH will recover personnel from hostile territory, conduct civil search and rescue, provide disaster relief, and evacuate non-combatants. Learning from the Combat Search and Rescue Replacement Vehicle program that was canceled in 2009, the Air Force reduced requirements for the CRH to lower the cost and ensure that no technology development is needed (GAO, 2013b).
- Costs Estimated for Prototyping Alternatives. 2 competing contractor prototypes during the EMD phase (\$725M).
  - Benefits Estimated. Reduction of software and integration risk (\$12M).
  - Schedule Impact. Unknown.
  - Type Contract for TMRR phase. None.
  - Type Contract for EMD phase. Fixed Price Incentive (Firm Target) with 50/50 share ratio.
  - Percent change in PAUC from development baseline. +1.2%.
4. **Enhanced Polar System (EPS) Program Control and Planning Segment (CAPS).** EPS will provide extremely high frequency, jam-resistant, and secure satellite communications to forces operating in the North Pole region. EPS consists of two payloads hosted on classified satellites, a gateway to connect user terminals to other communication systems, and a control and planning segment (CAPS) to control the payloads and manage communications (GAO, 2012b).
- Costs Estimated for Prototyping Alternatives. One additional prototype and funding for a second contractor through Preliminary Design Review (\$49M).
  - Benefits Estimated. Negligible (\$0).
  - Schedule Impact. 6 to 24 months.
  - Type Contract for TMRR phase. None.
  - Type Contract for EMD phase. Cost Plus Incentive Fee (CPIF) with 50/50 share ratio.
  - Percent change in PAUC from development baseline. -0.7%.
5. **F-15 Eagle Passive/Active Warning and Survivability System (F-15 EPAWSS) Program.** The program will replace and upgrade internal self-protection electronic warfare systems on fielded F-15C/E aircraft. EPAWSS consists of four major subsystems: radar warning receiver, electronic countermeasure processor, countermeasure dispenser system, and fiber-optic towed decoy. These subsystem capabilities will be fielded in two increments. The program entered the TMRR phase in August 2015 (GAO, 2015b).
- Costs Estimated for Prototyping Alternatives. (1) Competitive prototypes by 2 contractors (\$116.3M); (2) Single prototype by one contractor (\$38.3M); Critical subsystem prototyping by one contractor (\$36.3M).
  - Benefits Estimated. (1) \$7.2M; (2) 7.2M; (3) 6.5M.





- Schedule Impact. (1) 41 months; (2) 26 months; (3) 21 months
  - Type Contract for TMRR phase. Unknown.
  - Type Contract for EMD phase. Unknown.
  - Percent change in PAUC from development baseline. Unknown.
6. **Indirect Fire Protection Capability Increment 2, Block 1 (IFPC Inc 2 Blk 1) Program.** IFPC Increment 2 will detect, assess, and defend against threats from rockets, artillery, mortars, cruise missiles, and unmanned aircraft. Block 1 counters cruise missiles and unmanned aircraft (GAO, 2014d).
- Costs Estimated for Prototyping Alternatives. (1) Two competing contractor prototypes (\$208.5M); (2) Two in-house prototypes (\$219.6M).
  - Benefits Estimated. (1) \$9.8M; (2) \$9.8M.
  - Schedule Impact. (1) 24 months; (2) 24 months.
  - Type Contract for TMRR phase. Unknown.
  - Type Contract for EMD phase. Unknown.
  - Percent change in PAUC from development baseline. Unknown.
7. **Fleet Replenishment Oiler (T-AO[X]) Program.** Fleet oilers transfer fuel to Navy surface ships that are operating at sea. This non-developmental and commercial-based program replaces the Navy's 15 legacy T-AO 187 Class Fleet Replenishment Oilers. The acquisition strategy includes competitive contract awards for industry studies, detailed design and construction, and follow-on ship procurement (GAO, 2014e). On 5 April 2013, the MDA signed the program's Milestone B ADM citing no technology development required and low programmatic risk (Compendium, 2015).
- Costs Estimated for Prototyping Alternatives. Two prototypes (\$1,350M); One prototype (\$742M).
  - Benefits Estimated. None (\$370M); None (\$370M).
  - Schedule Impact. (1) 60 months; (2) 60 months.
  - Type Contract for TMRR phase. None.
  - Type Contract for EMD phase. Unknown.
  - Percent change in PAUC from development baseline. Unknown.
8. **Presidential Helicopter Replacement (VH-92A) Program.** The Navy's VH-92A helicopter will transport the President, Vice President, and heads of state. The program provides replacements for legacy VH-3D and VH-60N helicopters. Compared with the VH-71 program that was canceled in 2009, the VH-92A has reduced performance requirements. The acquisition approach is to integrate mature communications and mission systems into an existing commercial or military helicopter. Since programmatic and technology risks have been reduced, there is no TMRR phase (GAO, 2013c).
- Costs Estimated for Prototyping Alternatives. (1) One contractor producing system and subsystem prototypes (\$782M); (2) Two contractors producing system and subsystem prototypes (\$3,380M).
  - Benefits Estimated. (1) \$0; (2) \$542M.
  - Schedule Impact. (1) 16 months; (2) 16 months.
  - Type Contract for TMRR phase. None.



- Type Contract for EMD phase. Fixed Price Incentive (Firm Target) with 50/50 share ratio.
- Percent change in PAUC from development baseline. -0.5%.

## Appendix B. No Prototyping

1. **B61 Mod 12 LEP TKA.** The objective of the Air Force's B61 Modification 12 Life Extension Program (LEP) is to upgrade and improve the accuracy of the tactical nuclear weapons stockpile. The National Nuclear Security Administration (Department of Energy) is responsible for the B61 Mod 12 LEP warhead design, manufacture and assembly. The Air Force is responsible for the tail kit assembly (TKA) for use on aircraft, including the F-35 JSF and the B-21 Long-Range Strike Bomber. The MDA directed that the program move directly into the EMD phase, bypassing the TMRR phase and any early competitive prototyping. The first 35-month phase of a total 74-month EMD contract was awarded to Boeing in November 2012. Preliminary Design Review (PDR) was planned for January 2014, with Critical Design Review (CDR) in the summer of 2015. The development contract includes the requirement to build 77 engineering design models for testing and evaluation.
  - Competitive Prototyping Tests. None (TMRR phase bypassed).
  - TRL/MRL achieved through competitive prototyping. Not applicable.
  - Type Contract for TMRR phase. No TMRR phase or contract.
  - Type Contract for EMD phase. CPIF with 30/70 share ratio.
  - Percent change in PAUC from development baseline. -9.6%.
2. **F-22 Inc 3.2B Mod.** With this modification, the Air Force is improving the F-22 Raptor hardware and software with air-to-air missile upgrades (AIM-9X and AIM-120D), Geolocation 2, and other Electronic Protection capabilities. The modernization effort started as an engineering change proposal (ECP). However, early development and production cost estimates revealed that the ECP should become a separate ACAT 1D acquisition program (DoD SE FY12 Annual Report). The Materiel Development Decision (MDD) for the F-22 Inc 3.2B Mod was conducted in October 2011. The February 2012 R-2 Budget Exhibits for the program mention the use of an Avionics Integration Lab (AIL), but no prototyping. The program achieved Milestone B in June 2013.
  - Competitive Prototyping Tests. None. No prototypes were built.
  - TRL/MRL achieved through competitive prototyping. Not applicable.
  - Type Contract for TMRR phase. IDIQ
  - Type Contract for EMD phase. CPIF with 20/80 share ratio for EMD; CPFF for test execution.
  - Percent change in PAUC from development baseline. -2.3%.
3. **FAB-T-FET.** The Air Force's Family of Advanced Beyond Line-of-Sight Terminals (FAB-T) provides for survivable terminals for communicating strategic nuclear execution orders via jam-resistant, low probability of intercept waveforms through the Milstar and Advanced Extremely High Frequency (AEHF) satellite constellations. FAB-T includes both Command Post Terminals (CPT) and Force Element Terminals (FET). On 30 July 2015, Congress was notified by the USD(AT&L) that the FAB-T program had been



split into two subprograms for more effective management: CPT and FET. The FAB-T-CPT subprogram entered the Production and Deployment phase in October 2015. However, execution of the FAB-T-FET subprogram has been deferred, in part due to bomber aircraft requirements still under development by Air Force Global Strike Command and approval of the Acquisition Program Baseline (APB; DAES, 2016a).

- Competitive Prototyping Tests. None. No prototypes have been built.
  - TRL/MRL achieved through competitive prototyping. Not applicable.
  - Type Contract for TMRR phase. Unknown.
  - Type Contract for EMD phase. Not awarded yet.
  - Percent change in PAUC from development baseline. +4.1%.
4. **GPS OCX.** The Air Force's Global Positioning System (GPS) OCX program provides for a modernized satellite command and control (C2) system which replaces the current ground control system for legacy and new GPS satellites. OCX implements a modern flexible architecture with information assurance built in to address emerging cyber threats. The Air Force is taking a block approach to develop OCX, with each block delivering upgrades as they become available (DAES, 2016b).
- Competitive Prototyping Tests. None. No prototypes have been built.
  - TRL/MRL achieved through competitive prototyping. Not applicable.
  - Type Contract for TMRR phase.
  - Type Contract for EMD phase. Cost Plus Award Fee (CPAF)
  - Percent change in PAUC from development baseline. +21.2%.
5. **ICBM Fuze Mod.** The Air Force's Intercontinental Ballistic Missile (ICBM) Fuze Modernization (Fuze Mod) program entails the design and development of a form, fit, and function replacement for the current Mk21 fuze used on the W87 warhead. This is a cooperative effort between the Department of Energy's National Nuclear Security Administration (NNSA), the U.S. Navy, and the United Kingdom. The ICBM Fuze Mod program will leverage technologies, components, and development/production capabilities from previous work performed by the U.S. Navy and NNSA on the Mk5 fuze for Submarine Launched Ballistic Missile warheads. The Mk 5 fuze entered EMD in August 2012. The ICBM Fuze Mod program entered the EMD phase in August 2013 after 6.3 Development Engineering entry approval by the Nuclear Weapons Council (chaired by the USD[AT&L]). Entry was in accordance with DOE Instruction 5030.55. The equivalent milestone review in DoDI 5000.02 is Milestone B (R-2 Budget Exhibit, 2014).
- Competitive Prototyping Tests. None. No prototypes have been built.
  - TRL/MRL achieved through competitive prototyping. Not applicable.
  - Type Contract for TMRR phase. None. The TMRR phase was bypassed.
  - Type Contract for EMD phase. Sandia National Labs, Albuquerque, NM, MIPR; Northrup Grumman, Clearfield, CT, CPAF
  - Percent change in PAUC from development baseline. +1.0%.
6. **KC-46A.** The Air Force's Tanker Modernization (KC-46A) program will replace the aging fleet of air refueling tankers. Since the program is based



upon a commercial aircraft modified for air refueling and military avionics, the program bypassed the TMRR phase and any competitive prototyping. An EMD phase development contract was awarded to Boeing in February 2011. A successful PDR was conducted in April 2013. A Milestone C decision is expected in April 2016 (DAES, 2016a).

- Competitive Prototyping Tests. None. No competitive prototypes were built.
  - TRL/MRL achieved through competitive prototyping. Not applicable.
  - Type Contract for TMRR phase. None. TMRR phase was bypassed.
  - Type Contract for EMD phase. Fixed Price Incentive (Firm Target; FPIF) with a 40/60 share ratio.
  - Percent change in PAUC from development baseline. -8.2%.
7. **LCS MM.** The Mission Modules (MM) for the Navy's Littoral Combat Ship (LCS) provide Mine Countermeasures (MCM), Surface Warfare (SUW), and Anti-Submarine Warfare (ASW) capabilities. While EMD phase prototypes are currently in development and testing, early MM prototyping in the TMRR phase is unknown. This could be because the MM became reportable as an MDAP only when all three MM were combined into the single LCS MM program. However, the LCS MM program office feels that it is complying with DoD guidance and regulations because all MM were demonstrated in a relevant environment prior to MM integration with the LCS (GAO, 2015a).
- Competitive Prototyping Tests. None. No early LCS MM prototypes were tested on the actual LCS.
  - TRL/MRL achieved through competitive prototyping. Not applicable.
  - Type contract for TMRR phase. Unknown.
  - Type Contract for EMD phase. CPFF and CPAF
  - Percent change in PAUC from development baseline. -0.1%.

## Appendix C. Prototyping

1. **AMDR.** The Navy's next generation radar system for air defense and ballistic missile defense is the Air and Missile Defense Radar (AMDR). Using S-band radar, C-band radar, and a Radar Suite Controller, the AMDR will be deployed on Guided Missile Destroyer (DDG) 51 Flight III. TMRR phase prototypes of these AMDR components were developed by Lockheed Martin, Northrup Grumman, and Raytheon based upon contracts awarded in September 2010. An initial PDR was conducted prior to MS B with each of the three TMRR phase solutions. However, a system-level Preliminary Design Review (PDR) for the AMDR was not conducted until 27 August 2014 under the EMD contract awarded to Raytheon. The MDA had waived the requirement to conduct a system-level PDR prior to Milestone B (AMDR DAES, 2016).
- Competitive Prototyping Tests. Hardware components were prototyped by three contractors. Software was not prototyped (DoD SE FY2013 Annual Report).
  - TRL/MRL achieved through competitive prototyping. The TMRR phase demonstrated the critical technologies necessary for a scalable AMDR (DoD SE FY2013 Annual Report).



- Type Contract for TMRR phase. 3 FPIF contracts for \$85.392M each and 3 FFP contracts for \$10M each to LM, NG, and Raytheon (R-3 Budget Exhibit, 2011).
  - Type Contract for EMD phase. CPIF with 50/50 share ratio
  - Percent change in PAUC from development baseline. -10.5%.
2. **Chem-Demil ACWA.** DoD's Chemical Demilitarization–Assembled Chemical Weapons Alternatives (ACWA) program includes two chemical demilitarization plants designed to safely dispose of the chemical weapons stored at Blue Grass and Pueblo Army Depots. Instead of incineration, both plants use safe and environmentally sound neutralization alternatives. The program suffered a critical unit cost breach in 2010 and was rebaselined to cover risk and to prove out first-of-a-kind equipment development (Annual SAR, 2010). Since then, event-based technical reviews of a rocket cutting machine and a rocket shearing machine were conducted prior to the March 2012 Milestone B decision. Both machines were found ready for implementation. In addition, each plant was modeled to assist in understanding facility control system issues (DoD SE, FY12 Annual Report).
- Competitive Prototyping Tests. Component testing only as discussed above.
  - TRL/MRL achieved through competitive prototyping. Not available.
  - Type Contract for TMRR phase. Bluegrass, CPIF (awarded 13 June 2003); Pueblo, CPAF (awarded 27 September 2002)
  - Type Contract for EMD phase. Contracts from TMRR phase have been extended.
  - Percent change in PAUC from development baseline. +3.0%.
3. **EPS.** The Air Force's Enhanced Polar System (EPS) program will provide assured communications over the North Polar Region. The system consists of two communications payloads on host satellites in highly elliptical orbits. The EPS is composed of and managed in four segments: an extended data rate payload, user terminals (acquired separately by users), a fixed installation Gateway, and a fixed installation Control and Planning Segment (OUSD[AT&L], n.d.). The EPS payloads are a simplification of the Advanced Extremely High Frequency (AEHF) payloads, and the EPS segments use the mature extended data rate waveform with common Global Information Grid interfaces. Since technology was determined to be mature, the EPS program was directed in 2007 to proceed to Milestone B. Before that review, the EPS program office and contractor did analysis and modeling and conducted a Preliminary Design Review (PDR) at which an allocated baseline was established. The DoD Director of Systems Engineering assessed that allocated baseline for software development and determined that it lacked integration detail (DoD SE, FY13 Annual Report). Regardless, a successful Milestone B decision review was conducted on 2 April 2014. Today, the prime contractor, Northrup Grumman, is experiencing some unfavorable cost variance due to unplanned software and systems engineering, integration, and testing; however, there are no significant software development issues (DAES, 2016a).





- Competitive Prototyping Tests. Early prototyping included flight equivalent payloads, a gateway engineering development model, and prototype control and planning software (GAO, 2015a).
  - TRL/MRL achieved through competitive prototyping. Not available.
  - Type Contract for TMRR phase. Cost Plus Incentive Fee (CPIF)
  - Type Contract for EMD phase. CPIF with a 50/50 share ratio.
  - Percent change in PAUC from development baseline. -0.6%.
4. **F-35 Aircraft.** The Joint Strike Fighter (F-35 Aircraft) program develops, produces, and fields the next generation multi-role tactical aircraft. The three variants are F-35A Conventional Takeoff and Landing (CTOL) for the Air Force, F-35B Short Takeoff and Vertical Landing (STOVL) for the Marine Corps, and F-35C Aircraft Carrier suitable Variant (CV) for the Navy (DAES, 2016b).
- Competitive Prototyping Tests. Two competitive prototypes were built.
  - TRL/MRL achieved through competitive prototyping. Not available.
  - Type Contract for TMRR phase. CPAF/CPIF
  - Type Contract for EMD phase. CPAF/CPIF
  - Percent change in PAUC from development baseline. -5.3%.
5. **F-35 Engine.** The Joint Strike Fighter Engine (F-35 Engine) program involved competition between two contractors: General Electric and Pratt and Whitney. Due to cost, the DoD decided to go with just one contractor, Pratt and Whitney.
- Competitive Prototyping Tests. Prototypes were built by 2 different contractors (Pratt and Whitney and General Electric).
  - TRL/MRL achieved through competitive prototyping. Not available.
  - Type Contract for TMRR phase. CPAF/CPIF
  - Type Contract for EMD phase. CPAF/CPIF
  - Percent change in PAUC from development baseline. -4.7%.
6. **JAGM.** The Joint Air Ground Missile (JAGM) program is led by the Army with joint interest with the U.S. Marine Corps and U.S. Navy. The JAGM represents the next generation of aviation launched fire and forget missiles to replace the HELLFIRE laser and Longbow radar missiles. JAGM will be used by joint service aircraft for destruction of high value stationary, moving, and relocatable land and maritime targets from standoff range in day, night, adverse weather, and obscured battlefield conditions (DAES, 2016b).
- Competitive Prototyping Tests. Two contractors built prototypes to mature technologies and designs. Each contractor completed a flight test and a Preliminary Design Review (PDR). The program's four critical technologies were all approaching maturity before the EMD phase (GAO, 2015a).
  - TRL/MRL achieved through competitive prototyping. Not available.
  - Type Contract for TMRR phase. Unknown.
  - Type Contract for EMD phase. Not yet awarded (FFP contract planned).
  - Percent change in PAUC from development baseline. +0.2%.





7. **JLTV.** The DoD's Joint Lightweight Tactical Vehicle (JLTV) Program was one of the first programs to comply with competitive prototyping in the TMRR phase (at the time, competitive prototyping was a USD[AT&L] policy, not a statutory requirement). In October 2008, three separate Cost Plus Fixed Fee (CPFF) contracts, totaling \$239.8 million, were awarded for the design, development, modeling, simulation, fabrication, test, and test support of 24 JLTVs and companion trailers (JLTV DAES ExSum, 2016). The three vendor prototypes were subjected to endurance testing to demonstrate reliability and maintainability, user assessments of suitability, and ballistic testing to assess force protection requirements (DOT&E, 2011).
  - Competitive Prototyping Tests. During TMRR phase testing, the DOT&E reported that all three vendor prototypes had problems with mobility in soft soil and integrating government furnished mission equipment into the prototypes. Reliability was also an issue for all prototypes, falling well short of the threshold reliability of 2,400 mean miles between operational mission failure. In addition, during the TMRR phase, the JLTV underbody threat requirement was increased to that of the Mine Resistant Ambush Protected (MRAP) vehicle. As a result, this increased force protection requirement was not tested on the JLTV competitive prototypes (DOT&E, 2011; DOT&E, 2012).
  - TRL/MRL achieved through Competitive Prototyping. Not available.
  - Type Contract for TMRR phase. Cost Plus Fixed Fee (CPFF)/Cost Share
  - Type Contract for EMD phase. Three Firm Fixed Price (FFP) contracts, with a 14-month period of performance, for 22 vehicles and six trailers from each vendor (JLTV DAES ExSum, 2016).
  - Percent change in PAUC from development baseline. -16.2%.
8. **LCS.** The Navy's Littoral Combat Ship (LCS) is optimized for flexibility in the littorals as a system of systems, both manned and unmanned. The LCS will be reconfigurable with three mission packages: surface warfare, mine warfare, and littoral anti-submarine warfare (DAES, 2016b).
  - Competitive Prototyping Tests. Two competitive prototypes were built, each of a different design, by separate contractors.
  - TRL/MRL achieved through competitive prototyping. Not available.
  - Type Contract for TMRR phase. FPIF
  - Type Contract for EMD phase. FPIF
  - Percent change in PAUC from development baseline. +2.7%.
9. **NGJ.** The Navy's Next Generation Jammer (NGJ) is an electronic attack system that will provide significantly improved Airborne Electronic Attack capabilities against advanced threats through enhanced agility and precision jamming, increased interoperability, and greater coverage against a wide variety of radio frequency emitters. The NGJ system will be integrated on the EA-18G tactical aircraft to replace aging AN/ALQ-99 Tactical Jamming System (TJS) pods (DAES, 2016b).
  - Competitive Prototyping Tests. Four prototypes have been built and tested: flight demonstration pod, 8% scale model in a high speed wind tunnel, and component-level prototypes for testing of the Mid-Band 1 and Mid-Band 2 array subsystem.



- TRL/MRL achieved through competitive prototyping. Not available.
  - Type Contract for TMRR phase. Unknown.
  - Type Contract for EMD phase. Pre-MDAP, not awarded yet.
  - Percent change in PAUC from development baseline. Unknown. The NGJ development baseline cost estimate is not known yet.
10. **SDB II.** The Small Diameter Bomb II (SDB II) program is a joint program with the Air Force as the lead service. The SDB II is a 250 pound, air-launched, precision-glide weapon that can attack both stationary and moving targets in degraded weather conditions at standoff ranges. The SDB II uses millimeter-wave radar, infrared sensor, and semi-active laser technologies, in addition to GPS and inertial navigation. The SDB II also has a weapon datalink network for in-flight target updates, retargeting, weapon tracking, and weapon abort (DOT&E, FY15 Annual Report). The SDB II program entered the TMRR phase in 2006. Competitive prototype contracts (CPFF) were awarded to Boeing and Raytheon in May 2006. By October 2009, SDB II had completed a 42-month competitive TMRR phase. The program had a successful MS B review and entered the EMD phase on 29 July 2010 (R-2 Budget Exhibits, 2007, 2010, 2011).
- Competitive Prototyping Tests: Both contractor prototypes were subjected to free flight demonstrations, captive carriage on F-15s, and seeker testing at the component level. Each contractor's warhead was also tested for lethality (Director, OT&E FY09 Annual Report).
  - TRL/MRL achieved through competitive prototyping. Competitive prototyping lead to a near-CDR level of maturity prior to the down-select and MS B decision. One or both contractors were on track to achieve TRL 6 or greater and MRL 6 or greater by MS B (DoD SE FY09 Annual Report).
  - Type Contract for TMRR phase. Cost Plus Fixed Fee (CPFF)
  - Type Contract for EMD phase. Fixed Price Incentive (Firm Target; FPIF) with priced options for the first 5 production lots (FPIF, lots 1-3 and FP[EPA], lots 4 and 5).
  - Percent change in PAUC from development baseline. -21.3%.
11. **SF Inc 1.** The Air Force's Space Fence (SF) Ground Based Radar System Increment 1 (Inc 1) will provide space situational awareness by detecting and reporting objects in Low Earth and Medium Earth Orbits (LEO/MEO). The system will have an operations center and two radar sites operating at S-band frequencies. SF Inc 1 consists of the operations center at Reagan Test Site Operations Center Huntsville, AL, and one radar site located at Kwajalein Atoll, Republic of the Marshall Islands (OUSD[AT&L], n.d.). The program had a successful MS B in 3rd Qtr FY2014 and is now in the EMD phase. Negotiations are still underway with the potential host nation for the location for the second radar site (R-2, PE 0604425F, Project 65A009, February 2016).
- Competitive Prototyping Tests. Two working prototypes were built in the TMRR phase to reduce risk. Also used prototype assembly to validate production planning for IOC (DoD SE FY2012 and 2013 Annual Reports).



- TRL/MRL achieved through competitive prototyping. An Independent Program Assessment (IPA) in FY2012 assessed the two contractor designs as technically mature and validated by working prototypes (DoD SE FY2012 Annual Report).
  - Type Contract for TMRR phase. Firm Fixed Price (FFP)
  - Type Contract for EMD phase. Fixed Price Incentive (Firm Target) with a 20/80 share ratio.
  - Percent change in PAUC from development baseline. -4.9%.
12. **SSC.** The Ship to Shore Connector (SSC) is the Navy's replacement for the Landing Craft, Air Cushion (LCAC) class of ships. The SSC will project, sustain, and retrograde combat power from the sea, independent of tides, water depth, underwater obstacles, or beach gradient. The lead craft (funded with RDT&E, Navy) will be maintained as a test and training craft to test fixes to problems that arise during fleet introduction (R-2 Budget Exhibit, 2010). The SSC received Milestone B approval in June 2012. In July 2015, the program was granted approval to enter the Production and Deployment phase.
- Competitive Prototyping Tests. The Command Module (a subsystem) was prototyped (DoD SE FY2014 Annual Report).
  - TRL/MRL achieved through competitive prototyping. Not available.
  - Type Contract for TMRR phase. Cost Plus Fixed Fee (CPFF) and Firm Fixed Price (FFP)
  - Type Contract for EMD phase. Fixed Price Incentive, Firm Target (FPI [F]) to Textron, Inc. for detailed design and construction of lead test and training craft (Craft 100) and technical manuals.
  - Percent change in PAUC from development baseline. -6.7%.
13. **3DELRR.** The Air Force's Three Dimensional Long-Range Radar (3DELRR) is a replacement for the current legacy AN/TPS-75 Radar. The 3DELRR is a software intensive program that uses new semiconductor technology (gallium-nitride-based transmit/receive modules that have lower power requirements).
- Competitive Prototyping Tests. Three competing contractors built and demonstrated critical software elements and internal system integration.
  - TRL/MRL achieved through competitive prototyping. Results presented at the Preliminary Design Reviews from Technical Performance Measures indicate that the program is on track to meet its six KPPs and seven KSAs (DoD SE FY2013 Annual Report).
  - Type Contract for TMRR phase. Cost Plus Incentive Fee (CPIF; 1 contractor) and Firm Fixed Price (FFP; 2 contractors).
  - Type Contract for EMD phase. Fixed Price Incentive Firm Target (FPIF) planned.
  - Percent change in PAUC from development baseline. Unknown. The 3DELRR development baseline cost estimate is not known yet.





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# **An Assessment of Early Competitive Prototyping for Major Defense Acquisition Programs**

William R. Fast

[wrfast@nps.edu](mailto:wrfast@nps.edu)

831-656-3628

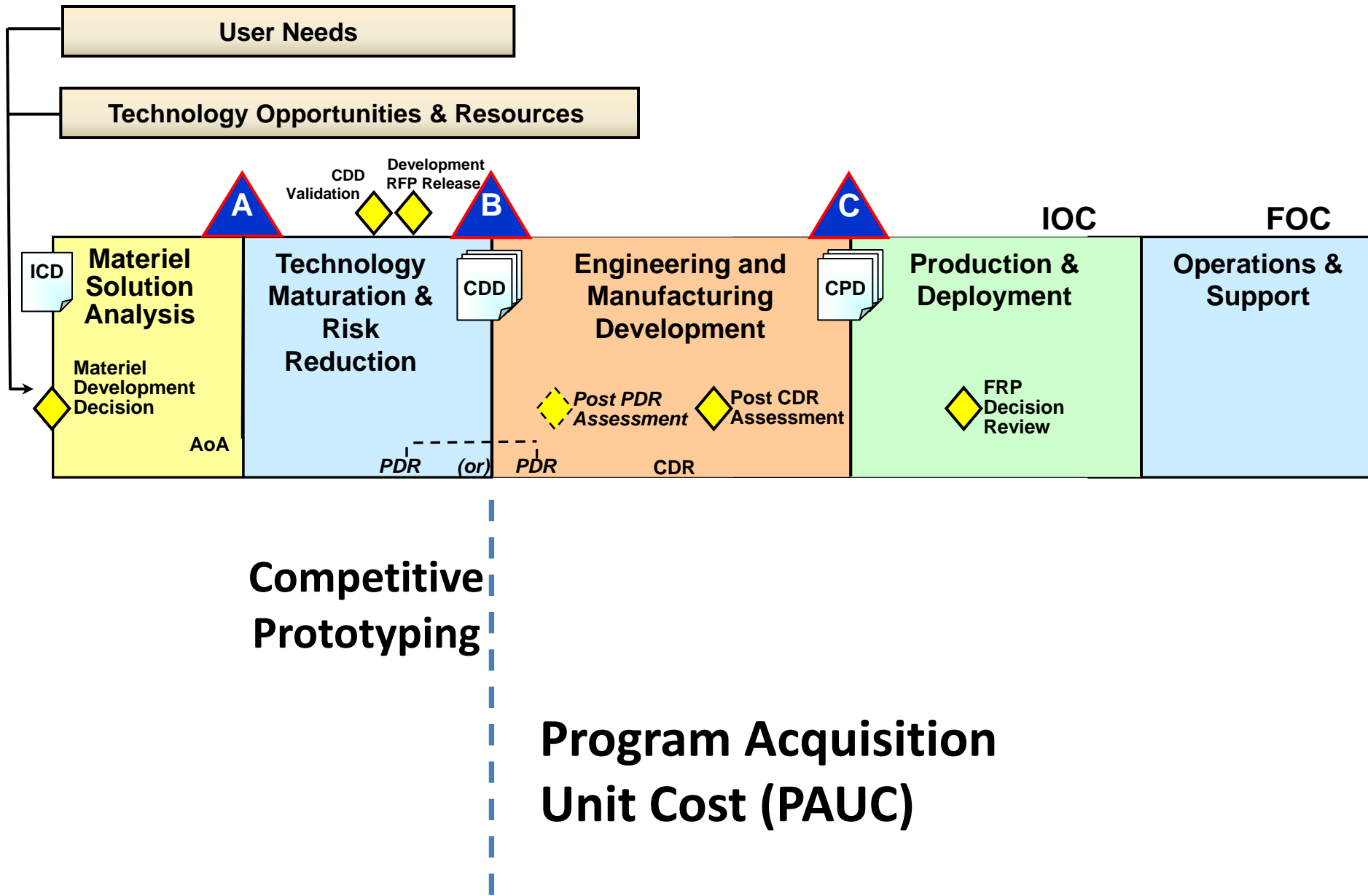
# WSARA and Prototyping

- Competitive prototyping of systems or critical subsystems before Milestone B approval
- If competitive prototyping is waived by MDA, a prototype must still be produced before MS B





# Defense Acquisition Framework

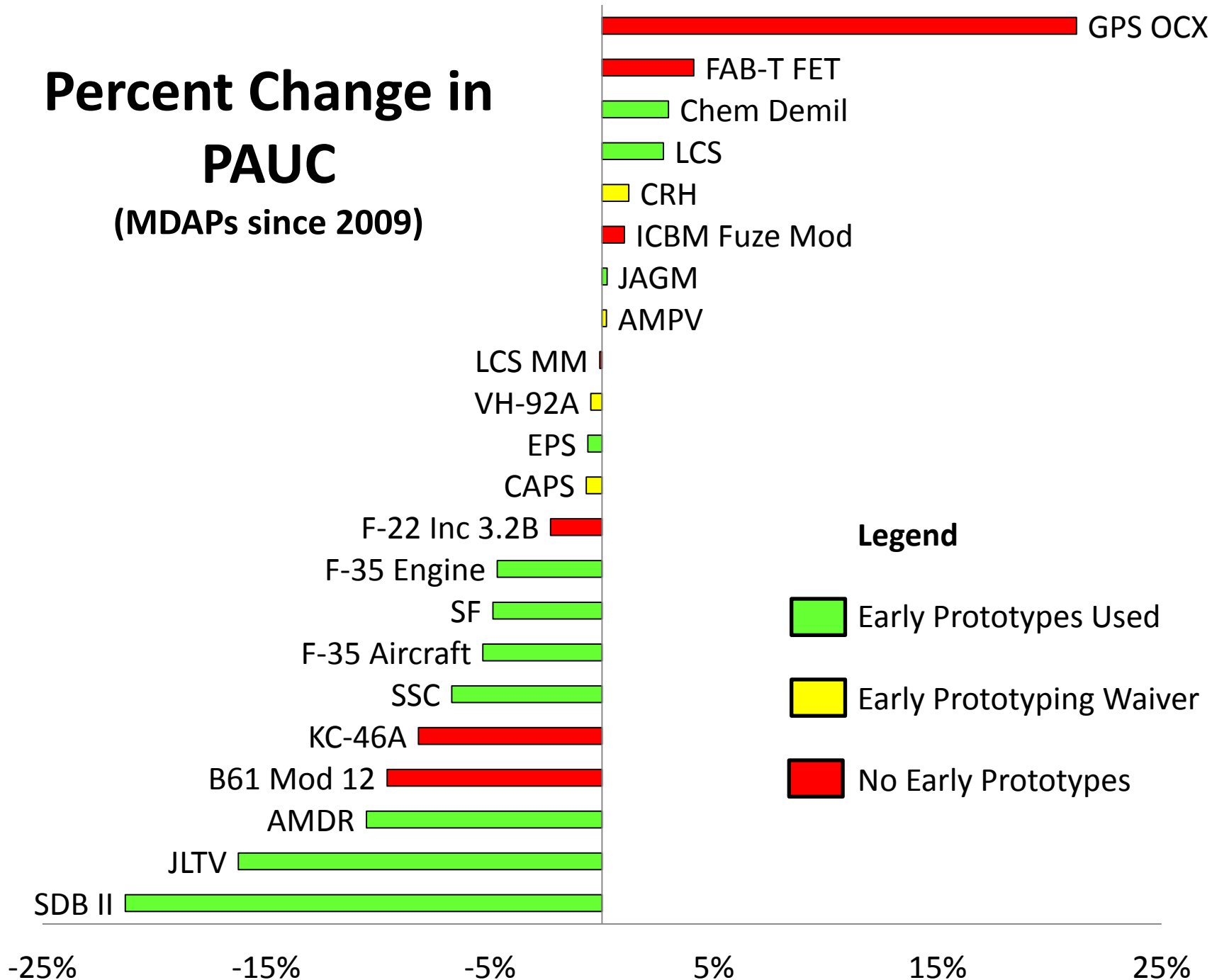


# Pre-MADPs and MDAPs Subject to Statutory Prototyping Since 2009

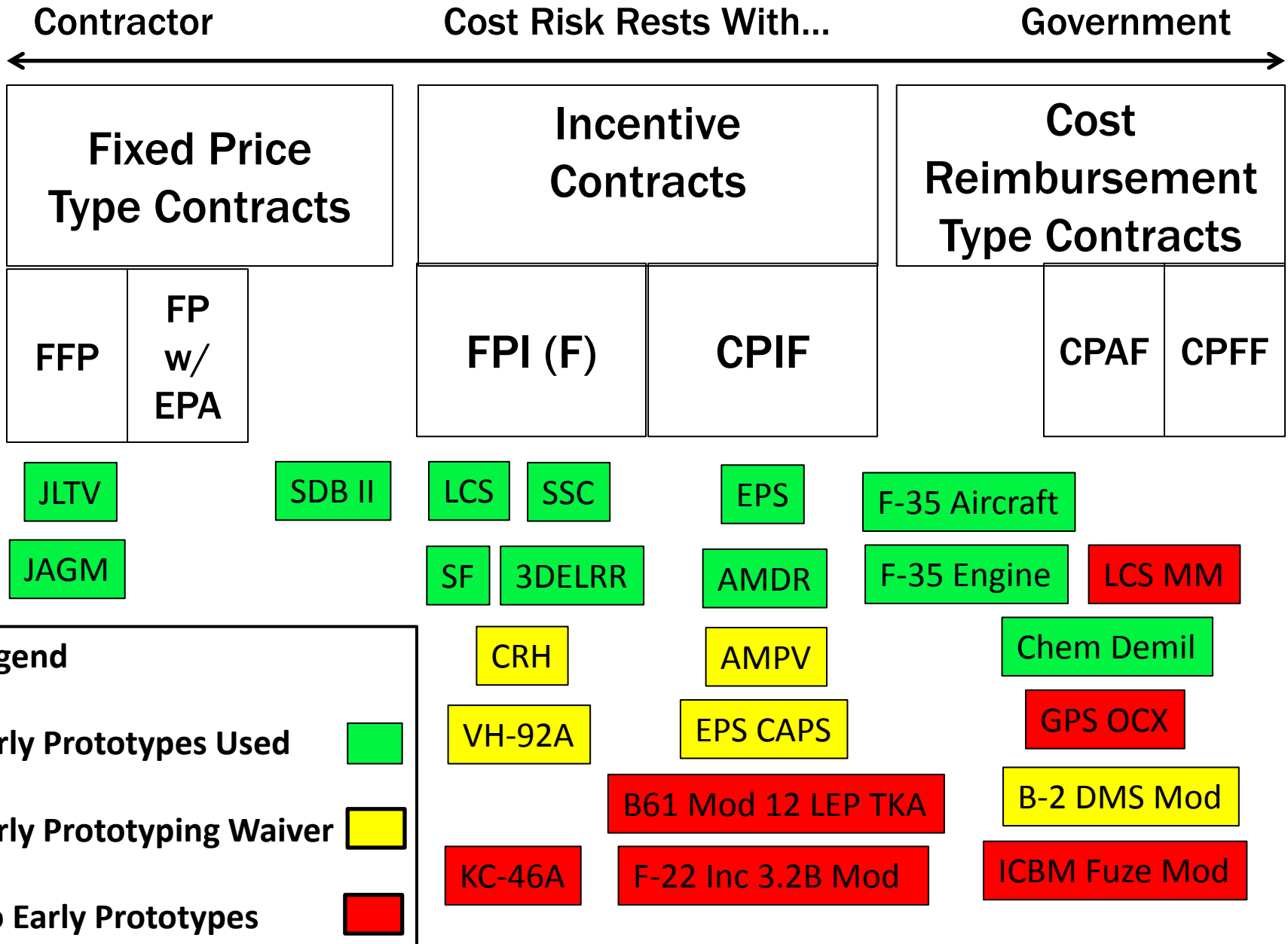
Waiver	No Prototyping	Prototyping
• AMPV	• B61 Mod 12 LEP TKA	• AMDR
• B-2 DMS Mod*	• F-22 Inc 3.2B Mod	• Chem Demil-ACWA
• CRH	• FAB-T FET	• EPS
• EPS CAPS	• GPS OCX	• F-35 Aircraft
• F-15 EPAWSS*	• ICBM Fuze Mod	• F-35 Engine
• IFPC Inc 2 Blk 1	• KC-46A	• JAGM
• T-AO (X)*	• LCS MM	• JLTV
• VH-92A		• LCS
		• NGJ*
		• SDB II
		• SF
		• SSC
*pre-MDAP		• 3DELRR*

# Percent Change in PAUC

(MDAPs since 2009)



# EMD Phase Contract Types



# Waiver of Early Prototyping (8 Programs)

- Minimal changes in PAUC
- Cost Reimbursement EMD Contracts – 3  
Fixed Price EMD Contracts – 2
- Rationale behind waivers
- GAO's Assessments:
  - Some waivers supported by Acquisition Strategy
  - Some waivers lacked prototyping alternatives or failed to dollarize prototyping benefits
  - Schedule impacts not quantified in dollars
  - Business Case Analyses not posted with assessments

Waiver
• AMPV
• B-2 DMS Mod*
• CRH
• EPS CAPS
• F-15 EPAWSS*
• IFPC Inc 2 Blk 1
• T-AO (X)*
• VH-92A
*pre-MDAP

# No Early Prototyping (7 Programs)

- Reductions in PAUC – 4 programs
- Increases in PAUC – 3 programs
- Cost Reimbursement EMD Contracts – 5
- Fixed Price EMD Contract - 1

No Prototyping
• B61 Mod 12 LEP TKA
• F-22 Inc 3.2B Mod
• FAB-T FET
• GPS OCX
• ICBM Fuze Mod
• KC-46A
• LCS MM

- All 7 programs bypassed TMRR, starting in EMD Phase
- Software Development and Systems Integration not considered as reasons for Early Prototyping



# Early Prototyping (13 Programs)

- Reductions in PAUC – 8 programs
- Increases in PAUC – 3 programs
- Fixed Price EMD Contracts – 5
- Cost Reimbursement EMD Contracts – 5
- Types of prototypes used

Prototyping
• AMDR
• Chem Demil-ACWA
• EPS
• F-35 Aircraft
• F-35 Engine
• JAGM
• JLTV
• LCS
• NGJ*
• SDB II
• SF
• SSC
• 3DELRR*
* pre-MDAP

# Joint Lightweight Tactical Vehicle (JLTV)



**USA / USMC**

**Contract Type**

**TD Contract Costs**

**Requirements**

**Tech Dev Phase**

**Prelim Design Rev**

**TRL / MRL**

**BAE Systems**

Various

\$62.9 M

**AM General/GDLS**

Various

\$61.3 M

draft CDD

27 months

June - July 2009

**Lockheed Martin**

CPFF

\$53.4 M

5 (underbody) / TMRR prototypes built on assembly line

# Small Diameter Bomb (SDB) II



**USAF / USN**

**Boeing / Lockheed**

**Raytheon**

**Contract Type**

CPFF

CPFF

**TD Contract Costs**

\$161.4 M

\$161.4 M

**Requirements**

validated CDD, June 2009; 5 KPPs

**Tech Dev Phase**

42 months

**Critical Design Rev**

within 6 months of MS B (June 2010)

**TRL / MRL (at MS B)**

6 / 6 (Program Office Estimates)

# Littoral Combat Ship (LCS)



USN	General Dynamics	Lockheed Martin
Contract Type	FPI	FPI
TD Contract Costs	\$575 M	\$537 M
Requirements	validated CDD, June 2008; 10 KPPs	
Tech Dev Phase	72 months	
Milestone B	Feb 2011	
TRL (at MS B)	? (integration w/mission packages) / ? (seaframe)	

# Cyclic Use of Prototyping

- Pre - WW II



- “Fly-Before-Buy”



- Packard Commission



# Rethink and Relearn Prototyping

- How to develop a sound business case
- Multiple competition-sensitive contracts
- Defending cost of multiple prototypes
- Understanding how ATDs and JCTDs fit in
- Competitive prototyping of critical subsystems